Introduction to Congestion Management with Flowgates

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Contract Path Approach

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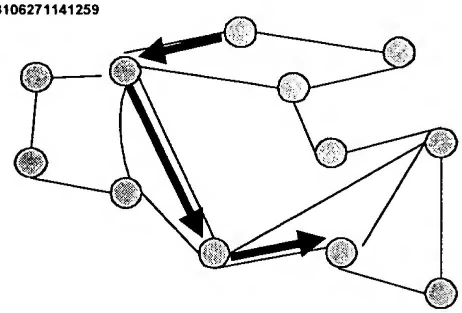

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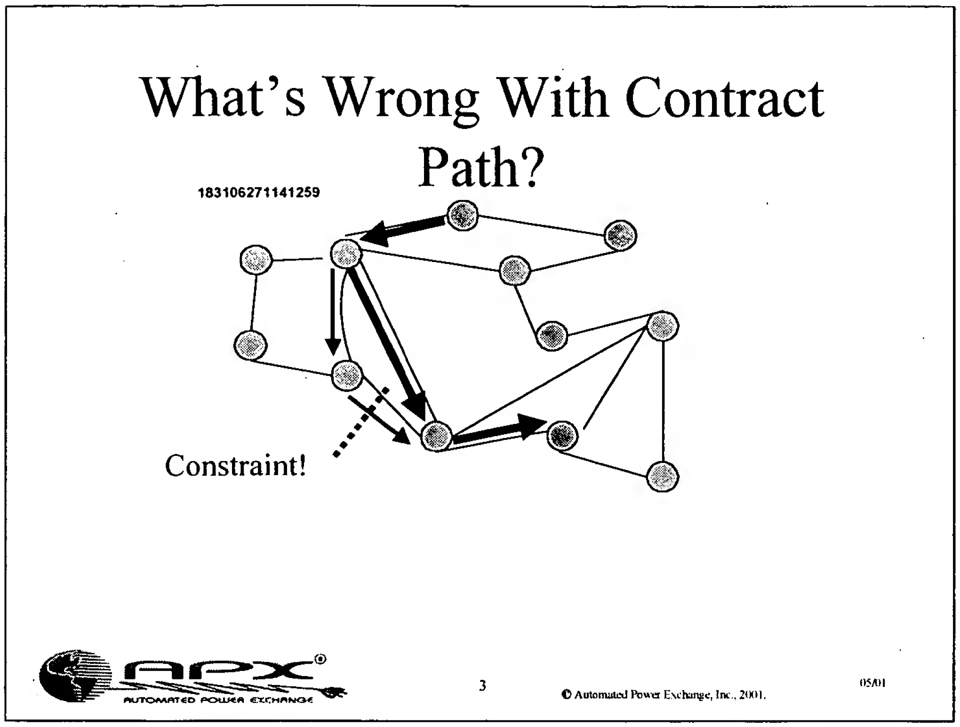
The transmission rights system most of us grew up with is the contract path approach. The concept was simple. You procure transmission on a link by link basis. All you need to do to set up a transaction is to reserve enough transmission capacity--on any routing--between the source generator and the sink load to cover the transaction.

In this example, a customer who wants to move power from location 5 to location 11 would simply reserve capacity on the interfaces between location 5 and location 4, between location 4 and location 12, and between location 12 and location 11.



Unfortunately, the contract path approach did not make for a workable market. Electric power does not actually follow the contract path, it follows the laws of physics, which means that it really flows to some degree over every possible path. As a result, congestion can develop even when every participant is doing exactly the transactions for which they reserved capacity.

In this example, some of the power flowing between location 5 and location 11 actually flows over the interface between location 3 and location 12, causing congestion on that link.

There are only two ways to deal with this problem with contract path scheduling. One is to be very conservative with the transmission bookings you allow, which wastes a lot of transmission capacity. The other is to curtail transactions as necessary whenever congestion develops. The latter alternative creates market chaos, since market participants cannot rely on their transactions going to delivery.

What Are the Consequences of Contract Path?

- Transmission reservations can't be honored--people trying to move power may be curtailed by transmission operators
- Curtailment priorities and procedures make the transmission market complicated and difficult to use
- System runs inefficiently because generators and customers do not have incentives to relieve transmission congestion, and transmission providers are conservative with their capacity offerings.

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There are other problems with the contract path approach worth noting.

In an effort to make curtailments fairer and more predictable, the industry (through the North American Electric Reliability Council- NERC) has adopted an elaborate set of priority rules for deciding whose transaction gets curtailed. While well intended, the result has been an extremely complex system of curtailment priorities, and a proliferation of transmission products, each with its own rung on the curtailment ladder. It has become very difficult to do business in this environment.

Furthermore, there are many things customers could be doing to mitigate congestion. However, the contract path approach provides no market incentives for participants to do so.

Aligning Transmission Reservations with Actual Flows

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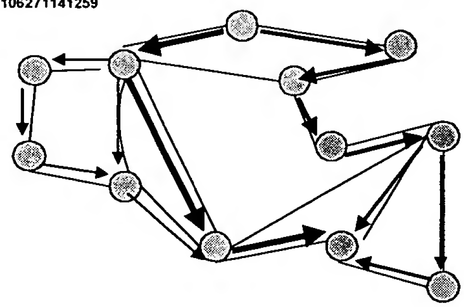

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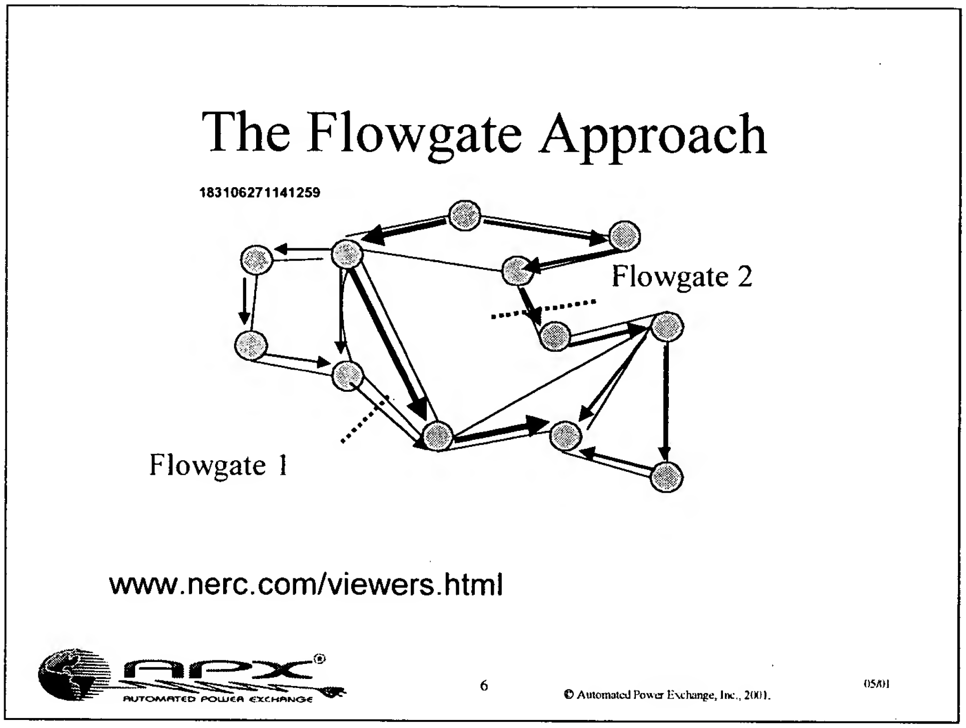
So what is the solution? The most obvious solution would be to require participants to book capacity on the transmission interfaces where their power actually flows. Then reservations and actual flows would be aligned, and no curtailments would be required. Unfortunately, most transactions affect many interfaces in the network, so such as system would be quite burdensome for the participants.

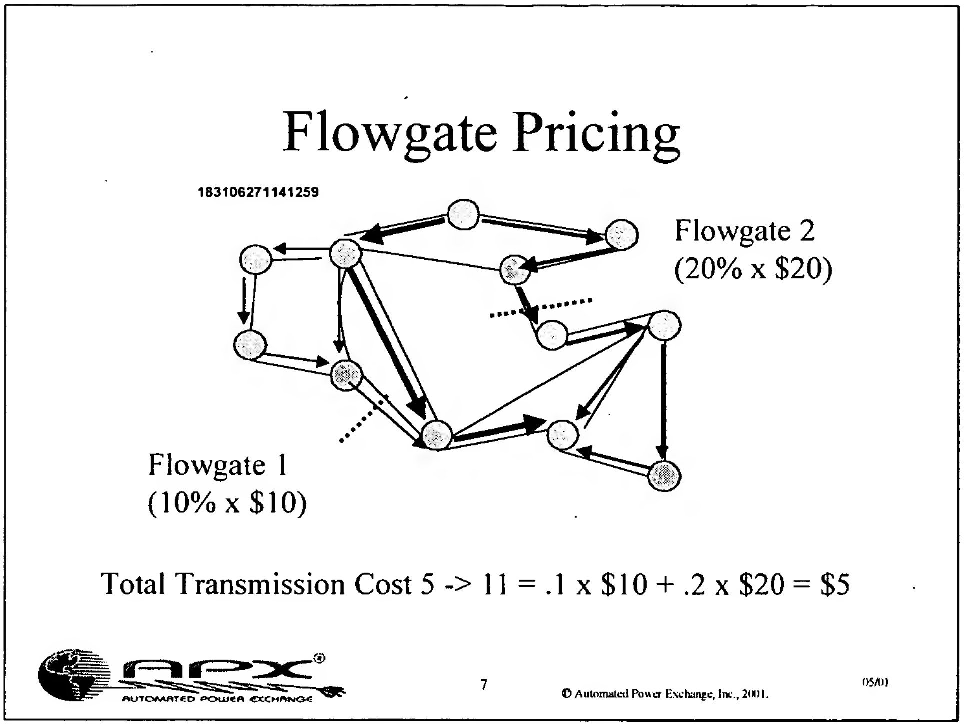
Fortunately, however, we do not have to go this far. Most of these interfaces are not congested, so why force participants to make reservations on them? Just have participants book reservations on the interfaces that are known to be congested. These are generally few, and generally well-known.



We call these congested interfaces "commercially significant constraints"or "flowgates".

Technologically, flowgates are not a new concept. In fact, security coordinators in the Eastern Interconnect already use a flowgate system to determine what transactions to curtail when congestion develops. Why not make a market in them?

In the Eastern Interconnect, the usage of each flowgate by each transaction is tracked in the NERC Interchange Distribution Calculator (IDC). You can go to the web address shown on this slide and calculate the flowgate requirements for any transaction you specify (although many of the flowgates shown there are not congested).

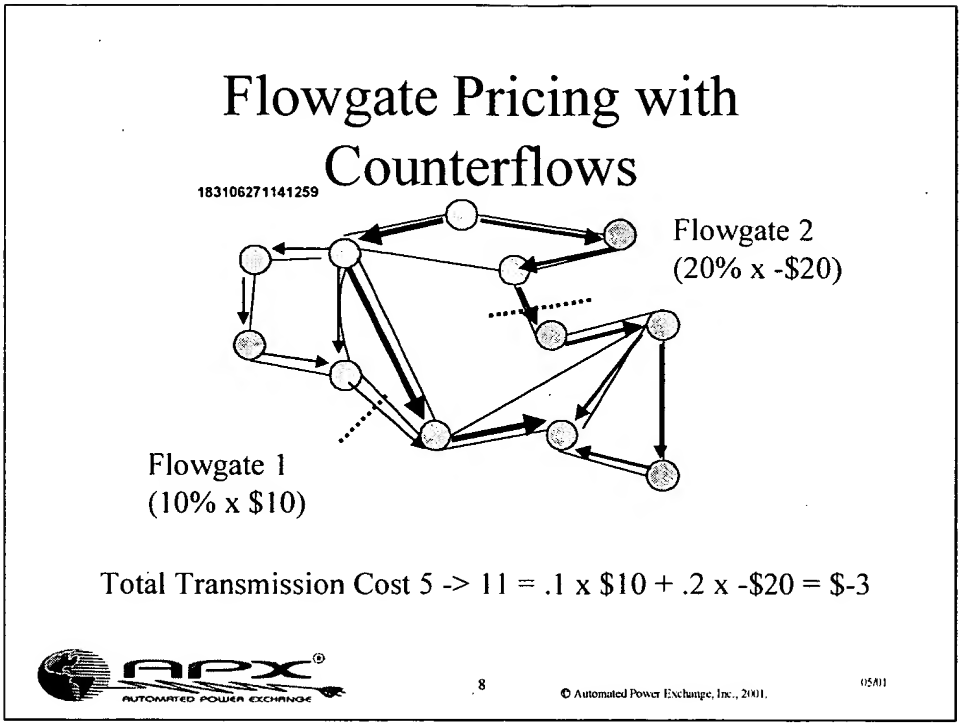


The solution here is to make a market in flowgate rights. Participants who wished to do a transaction would purchase rights to use the flowgates impacted by their transactions. Usage of each flowgate by a proposed transaction could be calculated similar to the way it is done in the NERC IDC. Software could make this easy for participants.

The RTO could conduct an initial auction of flowgate rights. After the initial auction, participants could trade flowgate rights with each other at prices that would be set by the market. Now we have a market solution that is consistent with the way power actually flows.

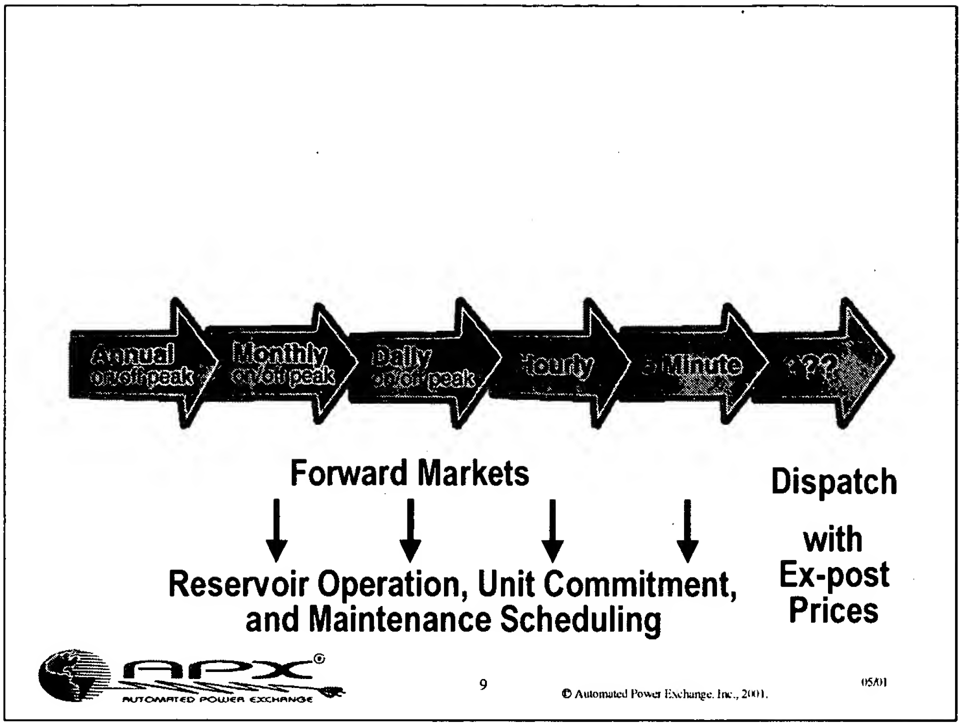
For example, let us assume that for a transaction for location 5 to location 11, 10% of the megawatts flow across flowgate 1 and 20% of the megawatts flow across flowgate 2. Then to do a 100 MW transaction, the participant would need to purchase 10 MW of flowgate 1 and 20 MW of flowgate 2. (To simplify the language a bit, we will often simply say "flowgates" when we mean "flowgate rights".)

If the market price of flowgate 1 was $10, and the market price of flowgate 2 was $20, the cost per megawatt moved from location 5 to location 11 would be 10% of $10 plus 20% of $20 for a total of $5.



There is another wrinkle to the flowgate approach that is especially interesting. Suppose that flowgate 2 were constrained in the opposite direction than before. In this case, a transaction from location 5 to location 11 is a counterflow across flowgate 2, which actually relieves congestion on that interface. The transaction would, in effect, create additional capacity on this flowgate, that other participants could use. It seems only reasonable that the participant who scheduled a counterflow that created additional flowgate capacity for others should be awarded flowgates equal to the additional capacity. The participant could then sell these flowgates to others, and be rewarded for helping to mitigate congestion. In this way, we create market incentives for participants to mitigate congestion.

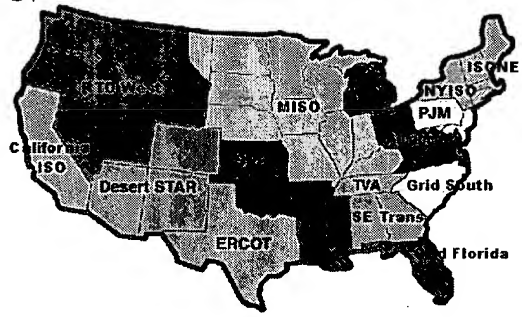
In the example in the slide, we assume that our transaction from location 5 to location 11 is a counterflow, creating capacity on the flowgate equal to 20% of the transaction amount. The participant would then incur a *negative* transaction cost for the transaction of $3 per MW. This means the participant gets paid to do the transaction, which is as it should be if the transaction is relieving congestion.



A major benefit of the flowgate market approach is that it provides price signals that enable efficient planning of operations. As in every industry, many decisions in the electric power industry demand advance planning. For example, hydro reservoir operation, maintenance scheduling, and unit commitment all demand planning well in advance for efficiency. Good planning requires knowing the time-dependent market prices of your inputs and output. Auction approaches to congestion management, such as today's LMP, do not provide these prices until shortly before delivery.

Flowgate markets, on the other hand, could operate continuously, much like financial markets. A current price quote for any product (energy or transmission) could be consistently available, thus allowing participants to make efficient planning decisions.

Flowgate Markets Can Resolve Seams Issues



- Reciprocity agreements between RTO's requiring participants in each RTO to purchase rights to all affected flowgates, regardless of the RTO in which the flowgate is located, are all that is required.

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Seams issues between RTO's are a major concern with auction based systems. How does one RTO insure that the transactions approved by a neighboring RTO will not cause congestion on its system? The laws of physics don't honor RTO boundaries.

Flowgate markets can resolve the seams issues between RTO's through simple reciprocity agreements. Participants would need to acquire flowgates on all of the flowgates their transaction affects, regardless of the RTO in which the flowgate was located. For example, a transaction across the New York ISO that impacted a flowgate in PJM would require rights to that PJM flowgate. The market thus not only helps resolve congestion within each RTO, but across RTO's as well.

Other Benefits of Flowgate Markets

- **Risk Management** - Customers can "lock-in" transmission costs in advance
- **Simplicity** - only one type of energy and one type of transmission needs to be traded. No filing of bid curves.

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Two other benefits of flowgate markets are worth mentioning. First, customers can easily manage their financial risks from transmission congestion. They simply buy the flowgates they need in the forward market, and their transmission cost will be "locked-in".

Flowgate markets are inherently simple. There really only needs to be one type of transmission and one type of energy--"firm"--traded, since a flow-based system can insure that curtailments will happen only in emergencies. As in most markets, when participants see a product they want to buy at an attractive price, they can buy it. There is no need to prepare auction submissions saying how much they might want to buy at each possible price.

Objections to Flowgate Markets

- Too many flowgates and reservations
  - Only need identify "significant" constraints
- Transmission providers cause congestion to get congestion revenues
  - Transmission providers don't get transmission revenues
- Liquidity
  - No compensation for unused flowgates

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It is worth taking a minute to address some of the objections frequently offered to flowgate markets.

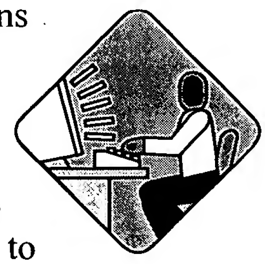
One is that there are too many flowgates. Richard Tabors has looked at this issue by running a market simulation of the full year 2003 with the GE MAPPS system. He found that only 115 flowgates in the entire Eastern Interconnect accounted for 90% of the congestion costs. In MAPP and MAIN combined, only 19 flowgates account for 90% of the congestion costs. I view these numbers as quite manageable.

Another objection frequently heard is that transmission providers would have an incentive to cause congestion in order to get additional revenue from flowgate sales. This should not be a problem if transmission providers remain regulated. Their revenue requirements would be covered by fixed access fees, as they are today. Revenues from the flowgate auctions would go to the RTO, who would use them to lower the access fees for everyone.

Others are worried that the flowgate market might not be liquid--a definite problem with the financial rights (FTR's, TTC's) offered under today's LMP systems. One reason FTRs are illiquid is that they are point-to-point rights, meaning that the number of potential rights is the square of the number of points. PJM has 2000 busses, implying they have 2000 squared possible FTR's. Also, with FTRs, you get compensated for your rights if you do not use them, so why bother to sell them? Neither problem should exist with flowgates.

Software Makes It Easy!

- Both energy and transmission could be traded through electronic exchanges, or bilaterally.
- No filing of schedules or reservations would be necessary--the exchanges could report the transactions to the system operators as they occur
- The system operators could use this information on the evolving market to plan their operations in advance



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In fact, today's technology makes managing all of the calculations and transactions that would make this system work quite painless. Both energy and transmission could be continuously traded in on-line exchanges, similar to trading stock through an on-line broker.

The exchanges could report each transaction to the system operators as they occur on a confidential basis (ordinary market participants would not have access to information on transactions by others). For the participants this would mean that no reservations or filing of schedules would be necessary. Whatever a participant's net transactions are when the market closes shortly before delivery is what will be scheduled.

For the system operators, this would mean that they would get to see the market as it has evolved at every stage. They would no longer have to wait for participants to file schedules to start planning their operations. The result should be greater efficiency, improved reliability, and lower stress.

Compatibility with Locational Marginal Pricing (LMP)

- LMP/ Flowgate Hybrid combines benefits of real-time LMP with benefits of forward flowgate markets
  - Customers may submit schedules with all, some, or no flowgates; all schedules flow, as in LMP
  - Customers who submit schedules with missing flowgates get charged for them at ex post LMP value
  - Customers who submit schedules with all flowgates are fully hedged against congestion costs

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Flowgate markets and LMP are not necessarily mutually exclusive. In fact, the SPP, Alliance RTO, the Midwest ISO all appear to be moving toward flowgate/LMP hybrid systems. These hybrid systems work like a flowgate system in the forward market, but allow participants to submit "uncovered" schedules (schedules without all required flowgates). Participants will be charged for the missing flowgates at a price generated by by the LMP system.

These hybrids give participants the flexibility of submitting schedules without flowgates, thus addressing remaining concerns about the liquidity of the flowgate markets and potentially large numbers of flowgates.

Pure Flowgate Approach

- Under pure flowgate approach, participants must procure flowgates in order to schedule
- Benefits
  - No need to combine existing control areas
  - Operator involvement in market minimized, since energy and flowgate trading can potentially continue to five-minute level
  - Need for ancillary services reduced or eliminated through real-time price responses

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The additional flexibility of the flowgate/LMP systems does, however, come at a price. LMP does not work very well across multiple control areas, since it needs to optimize over the entire system--ideally the entire interconnect. This is why LMP systems encounter seams problems between control areas. These seams problems also tend to become apparent in the hybrid approaches, unless we are willing to consolidate the existing control areas.

A pure flowgate approach, where participants must procure flowgates in order to schedule, minimizes involvement of the system operator. RTO West and Desert Start both appear to be moving in this direction.

Under a pure flowgate approach, energy and flowgate trading could potentially continue right down to the five minute level. A pure flowgate approach might eventually make it possible to reduce or eliminate the need for ancillary services. Real-time energy would be offered by providers (probably primarily dispatchable loads) who would stand ready for the occasional market opportunities afforded by a unit tripping off-line or other unscheduled events.

Basic Design Choice

RTO-HeavyRTO-Lite

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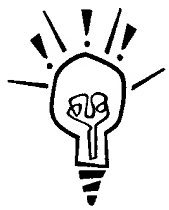
Flowgate markets afford an opportunity to have much simpler, easier to implement, and less expensive to operate RTO's. California, for example, spent $700 million dollars to build and operate the California ISO and California Power Exchange. The alternative is what I call "RTO-Lite". Under an RTO-Lite, the RTO could be organized without having to combine existing control areas, since the flowgate markets would resolve the seams issues between control areas. There would only need to be a small number of products--firm energy, firm transmission, and, at first, ancillary services. Trading would be done bilaterally, or through competitively organized exchange markets. Prices would be determined by the market, not the RTO.

The Demo

Market Vision

Energy Market



Easily find best energy deal, taking into account the transmission costs

Transmission Market

Easily track and trade flowgates needed to deliver the energy

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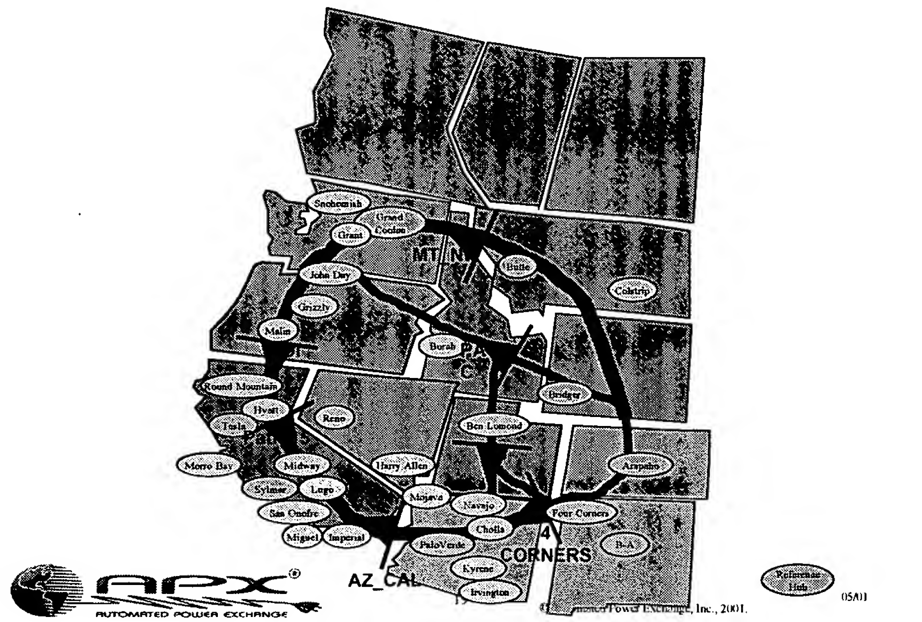
Our demo is designed to show how we can smoothly integrate the transmission and energy markets. The idea is that you should be able to easily find the best energy deal for you, taking into account transmission costs. At the same time, you should be easily able to track and trade the flowgate rights needed to deliver the energy.

Assumed Flowgates and Hubs



The demo is built around a simplified flowgate system for the Western Interconnect in North America. This map shows the network configuration. The seven "witches hats" represent the major flowgates. The orange circles represent power plants. The greenish circles represent loads. We use Grand Coolee as the reference node.

Assumed Flowgate TDF's

How many MWs of each flowgate does it take to get one MW of energy from Grand Coulee to...?

FlowgatesLoadAreas						Northwes	t0000000Monta

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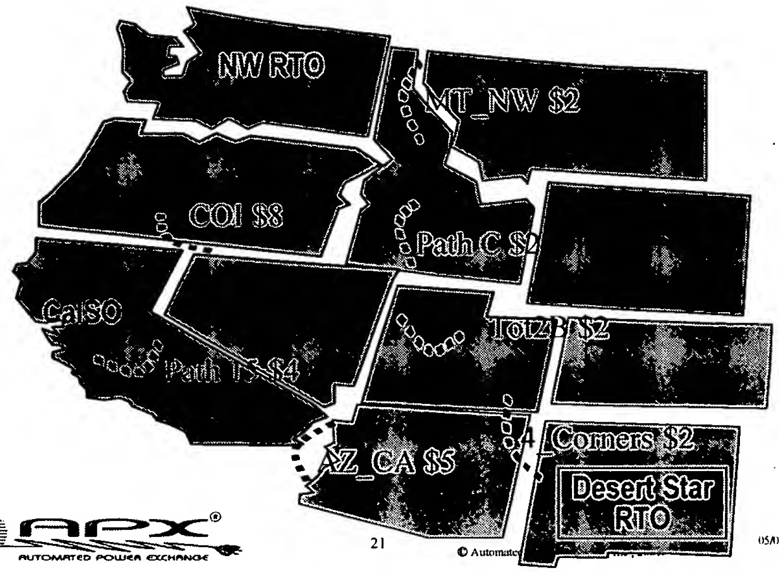
This slide shows our assumed transmission distribution factors, which are based on preliminary work for the flowgate system actually being developed by RTO West. The distribution factors show how many units of each flowgate you need to move one unit of energy from Grand Coolee to each of the load areas shown. We choose Grand Coolee as our reference here, but that was strictly arbitrary. Once you know these factors, it is straightforward to calculate the flowgate requirements to move energy between any two zones. These TDF's are, of course, a function of how power physically flows over the network.

Flowgate Pricing Assumptions



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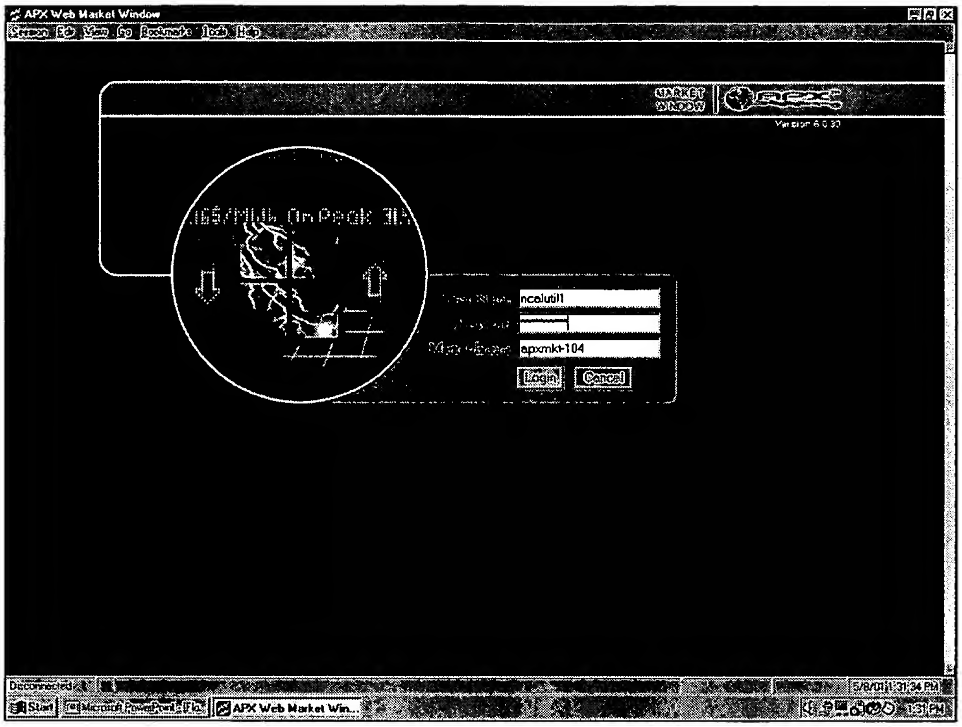
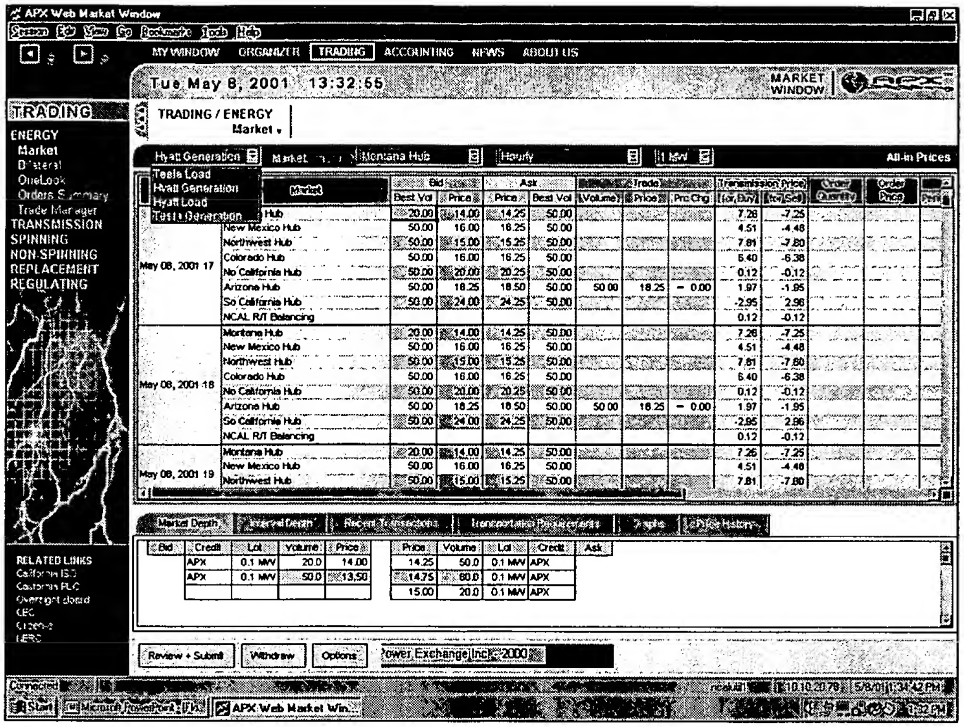
These are the flowgate prices I assumed for the demo. These are strictly my assumptions. In actual practice, these prices would be set by buyers and sellers in the market place. They are NOT fixed by any tariff or regulation.

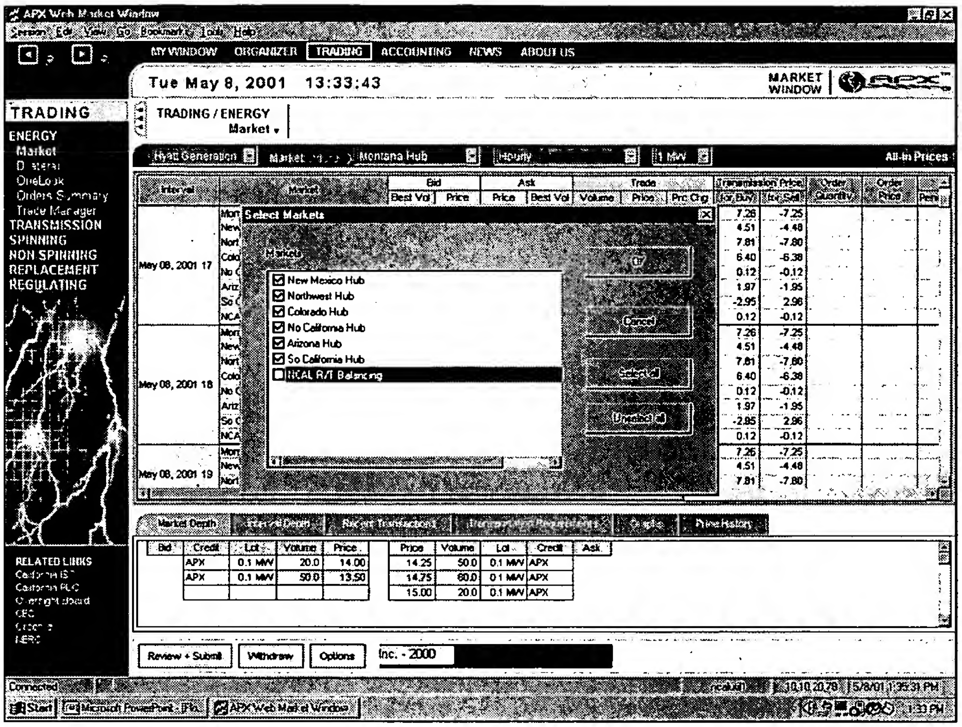


Now we switch the the APX Market Window for our demo. We will be using the next generation APX Market Window, currently under development, with some special adaptations to handle flowgate trading.

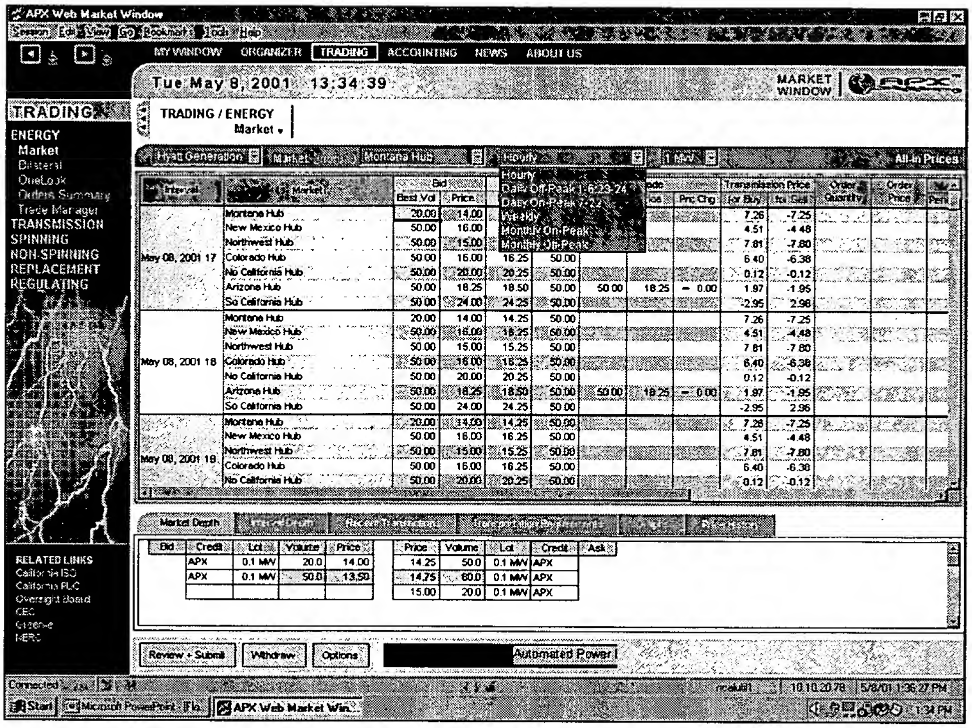
This is the screen for logging in to the APX Market Window. I am logging in as a utility in Northern California.



Participants in the market would register their generators and loads with the market operator. The first step in doing a trade would be for the participant to select the generator or load for which they wish to sell or buy energy. This would be accomplished simply by selecting the appropriate generator or load from the pull down menu at the top left of the screen, as shown above.

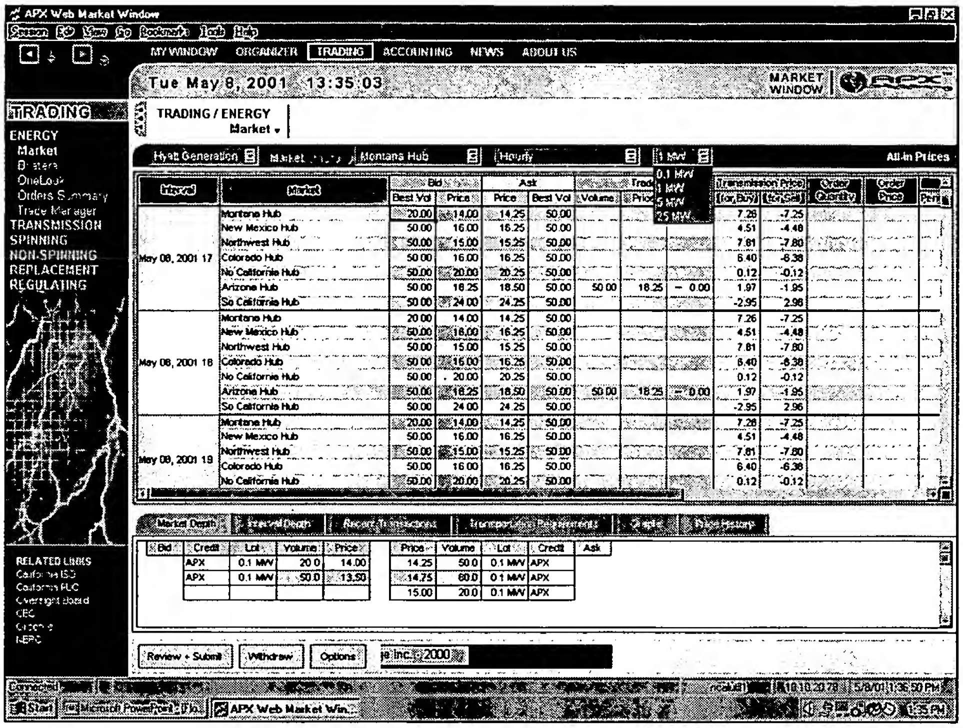


The participant could select the markets to be displayed on the screen by clicking on the words "Market (more)" to the right of the generator or load. The participant would then select the markets they wish to display from the menu that appears, as shown above. In this example, the markets are trading hubs within the WSCC. Markets could be selected by simply checking or unchecking the box next to each market name. We won't be looking at the real-time balancing market here, so we don't check it.

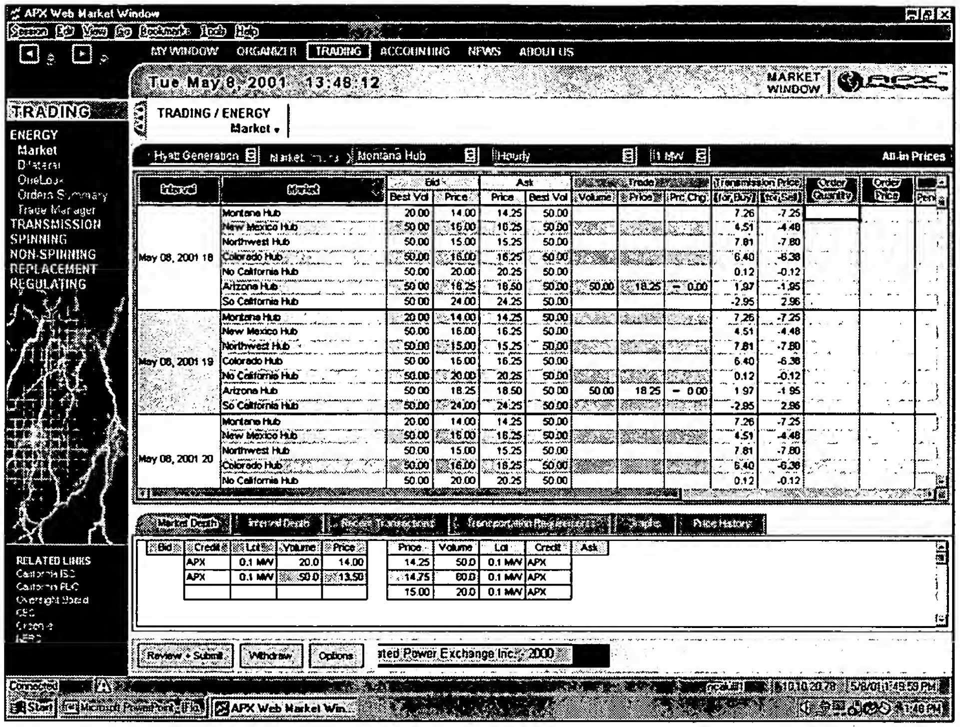


Whatever markets the participant has selected now appear in the second column, the "Market" column, in the center part of the screen. The first column shows the date and hour being traded, the "Interval".

Returning to the top of the trading window, participants would also select the strip they wish to trade, using the pull-down menu shown above. Since our example is for hourly energy trading, participants would select the hourly strip. However, this market could be more than an hour-ahead market. Real-time balancing energy or ancillary services energy could be traded in 5 or 10 minute strips. Longer term strips, such as daily on-peak and daily off-peak, weekly, monthly, or annual could also be offered.

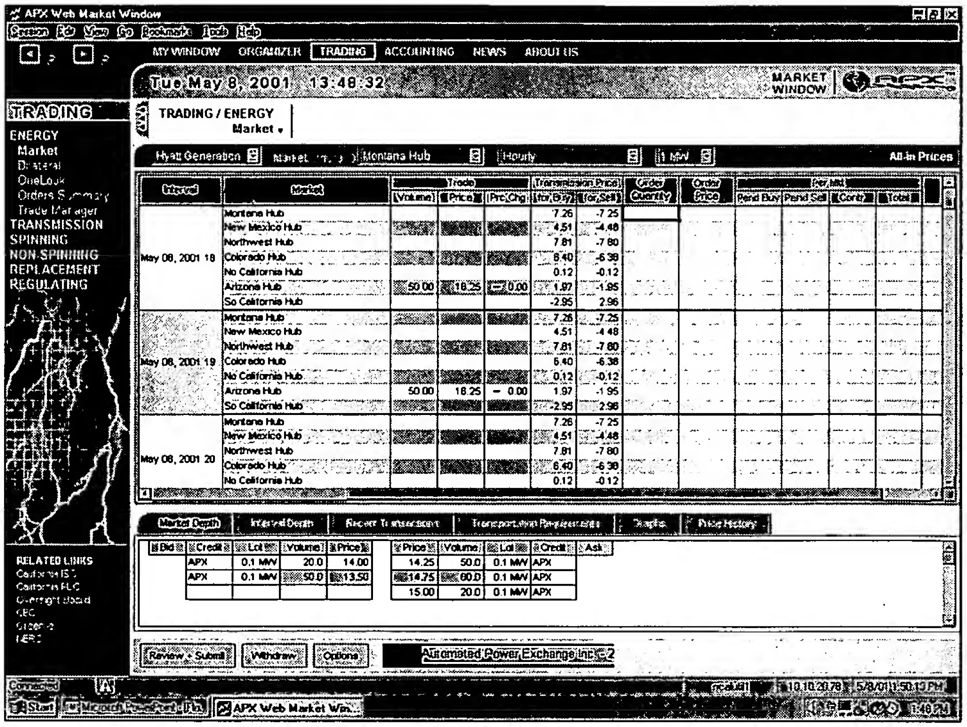


Finally, participants would select the lot size they wish to trade, using the pull-down menu shown above. Participants who wished to trade only in blocks of a certain size would thus be allowed to do so.



The center portion of the screen is the main trading interface. The "Interval" column specifies (for hourly markets) the date and hour being traded. The "Market" column defines the markets in which the participant can trade. The two "Bid" columns show the highest bid price currently offered in each market, along with the volume bid at that price. Similarly, the "Ask" columns show the lowest asking price currently offered in each market, along with the volume asked at that price. The "Trade" columns show historical activity in the market, including total volume traded, price of the last trade, and the last change in price.

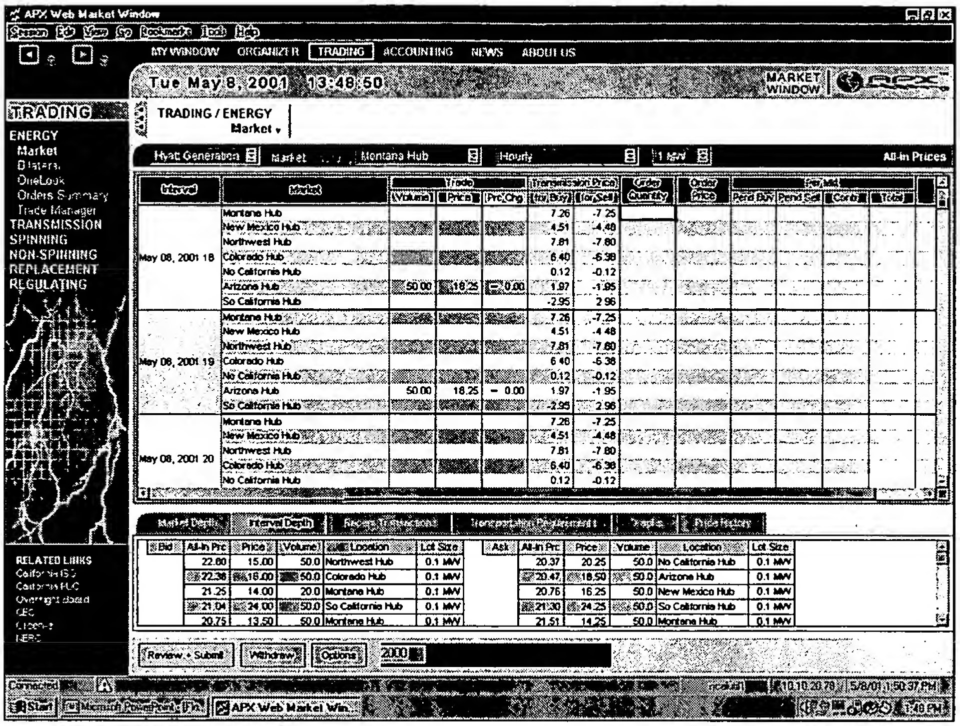
A unique feature of the proposed flowgate trading system are the next two columns, the "Transmission Price" columns. The "for Buy" column shows the participant's cost of delivering energy from each market to the participant's load. The "for Sell" column shows the participant's cost of delivering energy to each market from the participant's generator. These prices are calculated from the bid and offer prices in our flowgate market, that we will be seeing shortly, using the distribution factors I displayed earlier.



In this sample screen, some of the transmission prices are negative. In these cases, the proposed transaction would be creating a counterflow, so the participant would be awarded flowgate rights if they chose to do the transaction.

The bottom portion of the screen shows the bid and offer (ask) stacks for the market and interval highlighted by the participant in the center portion of the screen. The bids are on the left, and appear ranked by price attractiveness, meaning that the highest bid appears at top (in this case, a bid for 20 MW at \$14.00). Asks are on the right, and are also ranked by price attractiveness, meaning that the lowest ask appears at the top (in this case, an ask for 50 MW at \$14.25).

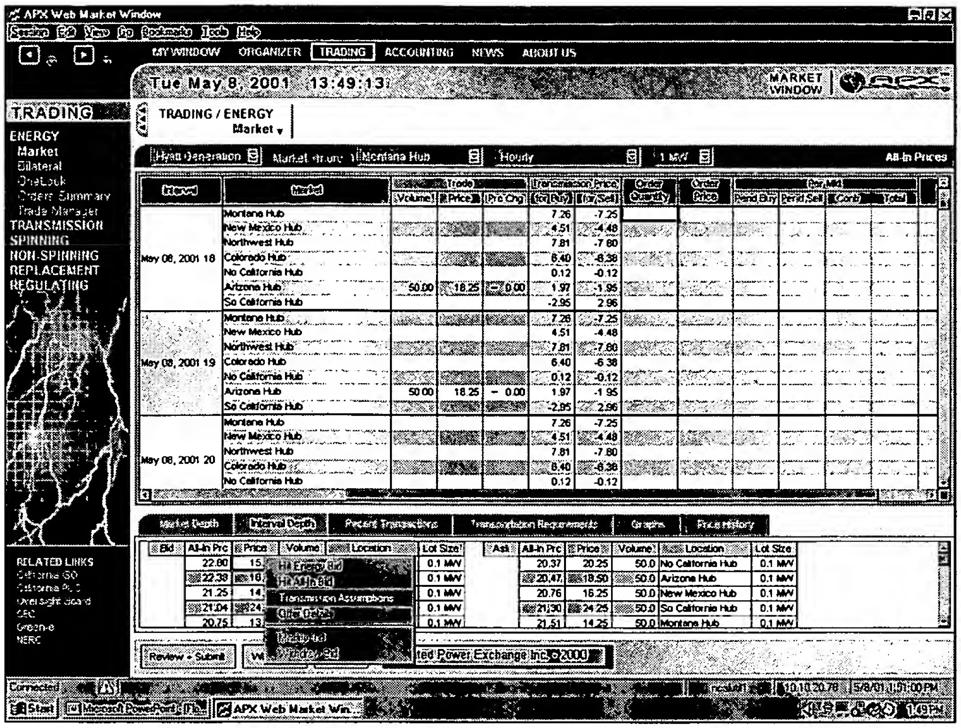
For bids, the participant should add the cost shown in the "Transmission--for Buy" column to obtain the total all-in price delivered to the participant's load. For asks, the participant should subtract the cost shown in the "Transmission--for Sell" column to obtain the net all-in price received by the participant's generator.



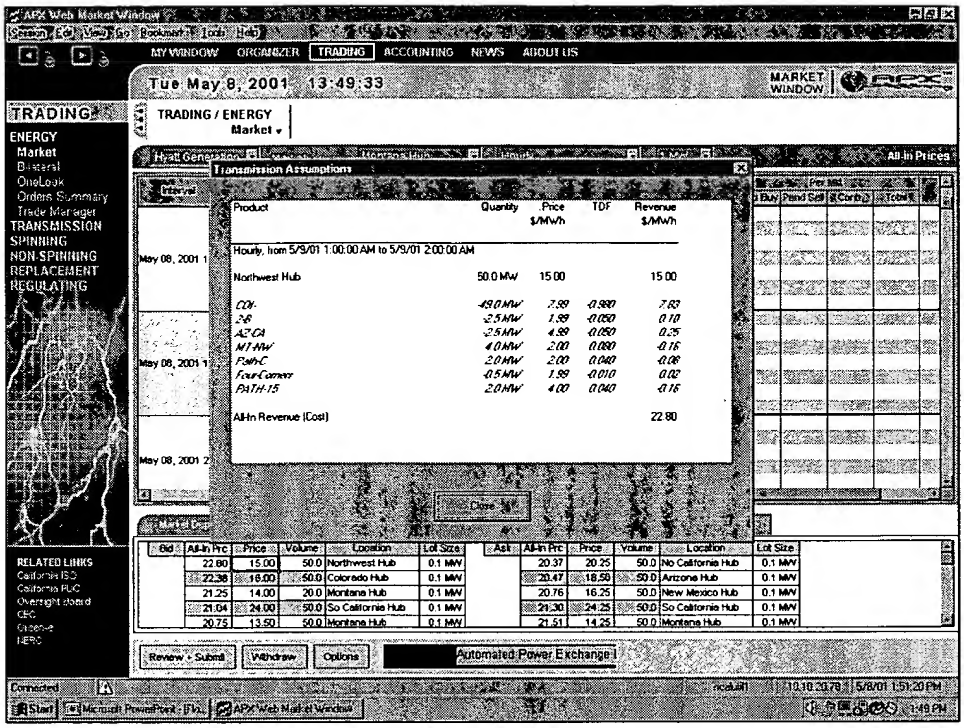
To select the best deal, the participant could get out their calculator and go through each market and calculate the best all-in price in each market, in order to select the best market in which to trade. However, the software has conveniently automated this activity.

If the user clicks on the "Interval Depth" tab at the bottom of the screen, bids and asks in all the selected markets will be shown, along with their all-in prices. These "Interval Depth" bid and ask stacks are completely analogous to the individual market bid and ask stacks, except that they are ranked by all-in price (energy - transmission for a bid, energy + transmission for an ask), rather than simply the price of the energy alone. This "Interval Depth" display thus allows the participant to easily select the best energy deal currently available in the market, taking into account the transmission costs.

The best deal for the Northern California generator shown in this example turns out to be in the Northwest, where the transmission cost is a negative $7.65. Since the energy bid is $15, the all-in price to the generator is $22.65.

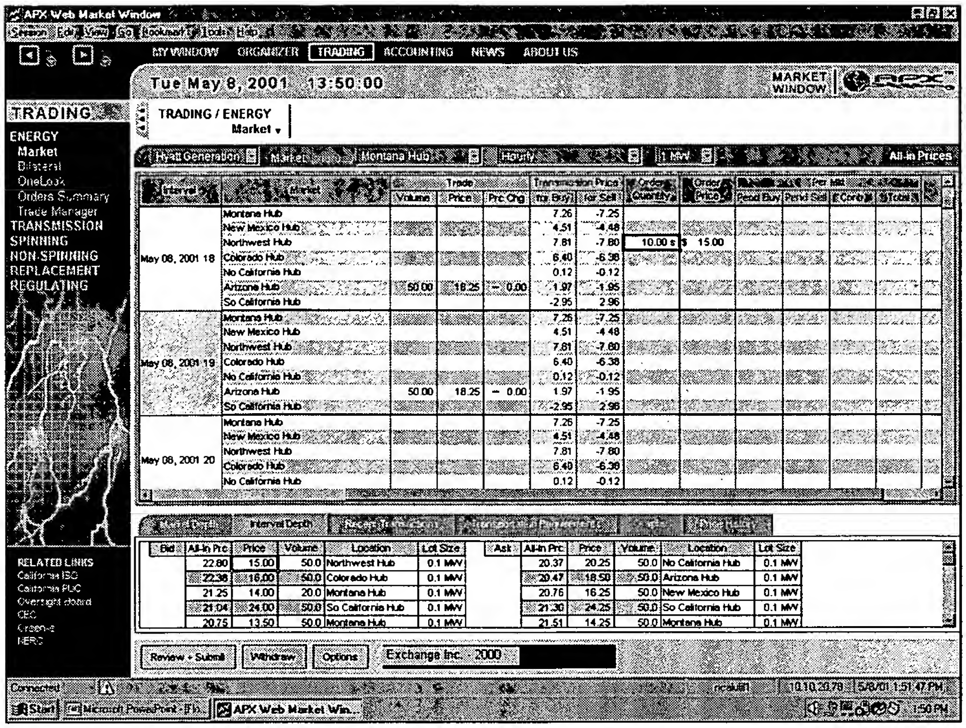


If the participant wanted to know what flowgates were included in the all-in price, the participant could simply highlight the desired bid (or ask), left click, and select "Transmission Assumptions" from the resulting pop-up menu, as shown.

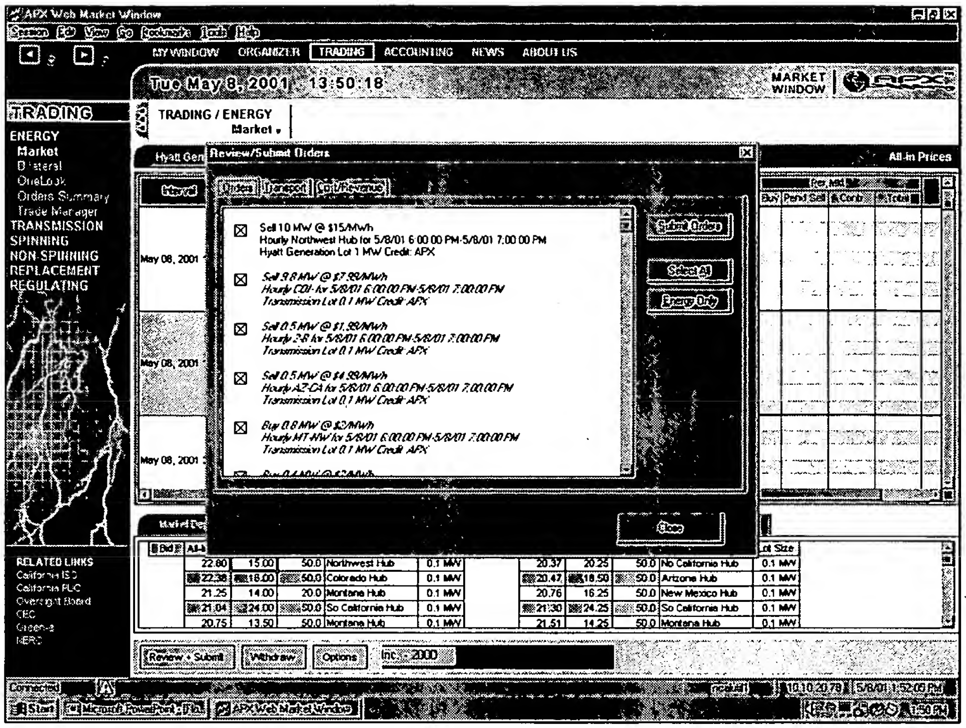


The resulting pop-up window displays the products encompassed in the all-in bid. The first data row displays the energy product, including its quantity, price, and total revenue. The remaining rows display the flowgates required to deliver that energy.

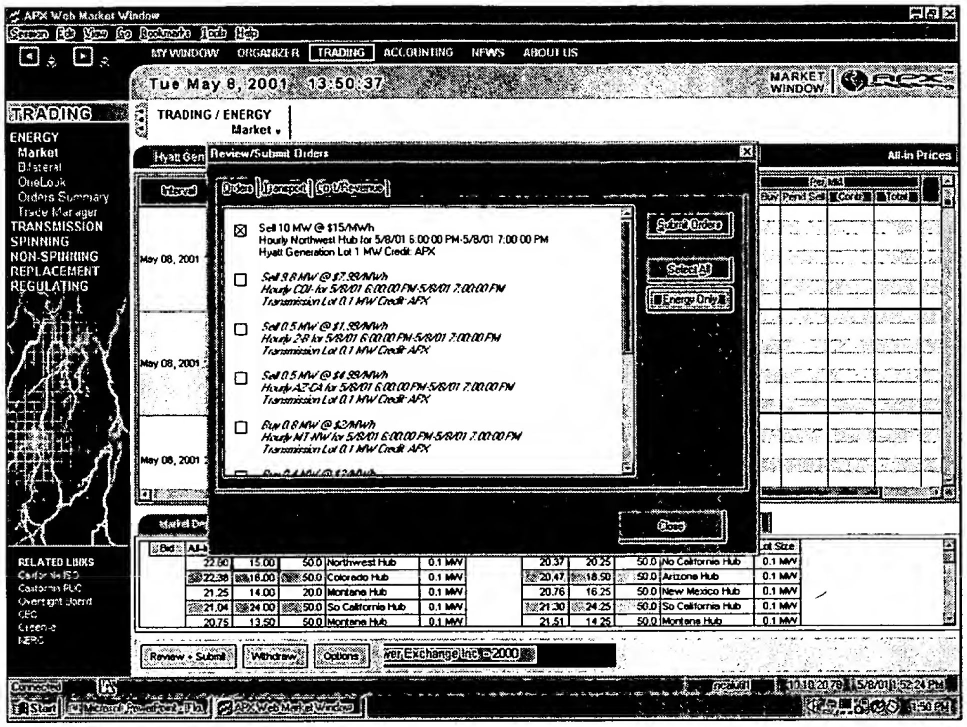
The column market "TDF" shows the distribution factors.



Having determined that the $15 bid in the Northwest is the best deal for our participant, let us assume the he/she wished to hit that bid. The participant enters a bid for 10 MW in the row for the Northwest market in the "Order Quantity" column, and puts a limit price of $15 in the "Order Price" column. Actually, this latter step is unnecessary, since if the participant left the "Order Price" column blank, the order would become a market order, that would automatically be matched with the best bid.

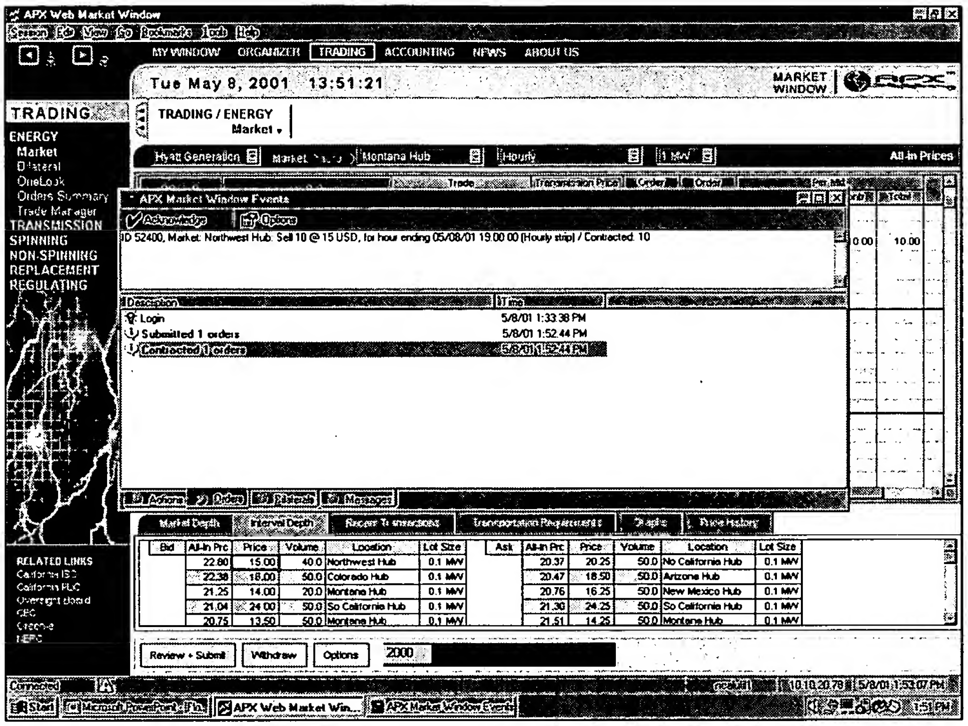


The participant then clicks the "Review + Submit" button in the lower-left corner, and the system automatically displays the energy order, along with all of the flowgates needed to deliver that energy.

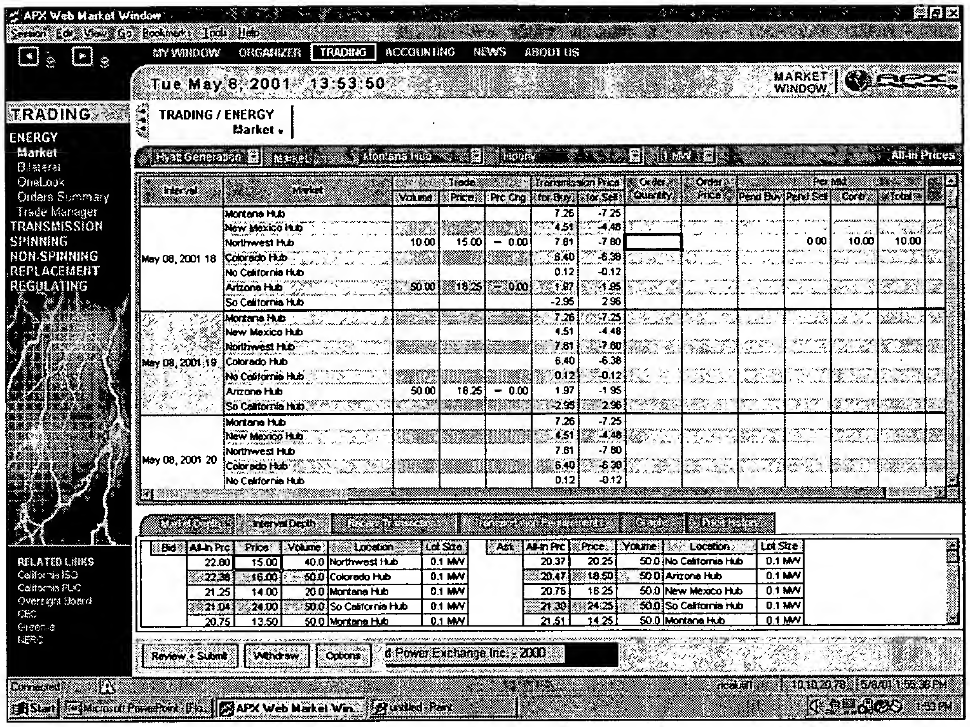


By clicking the "Energy Only" button, the participant can elect to buy only the energy. Or, the participant can check or uncheck the energy and various flowgates individually. For now, let us assume the participant, for whatever reason, has decided to buy the energy only.

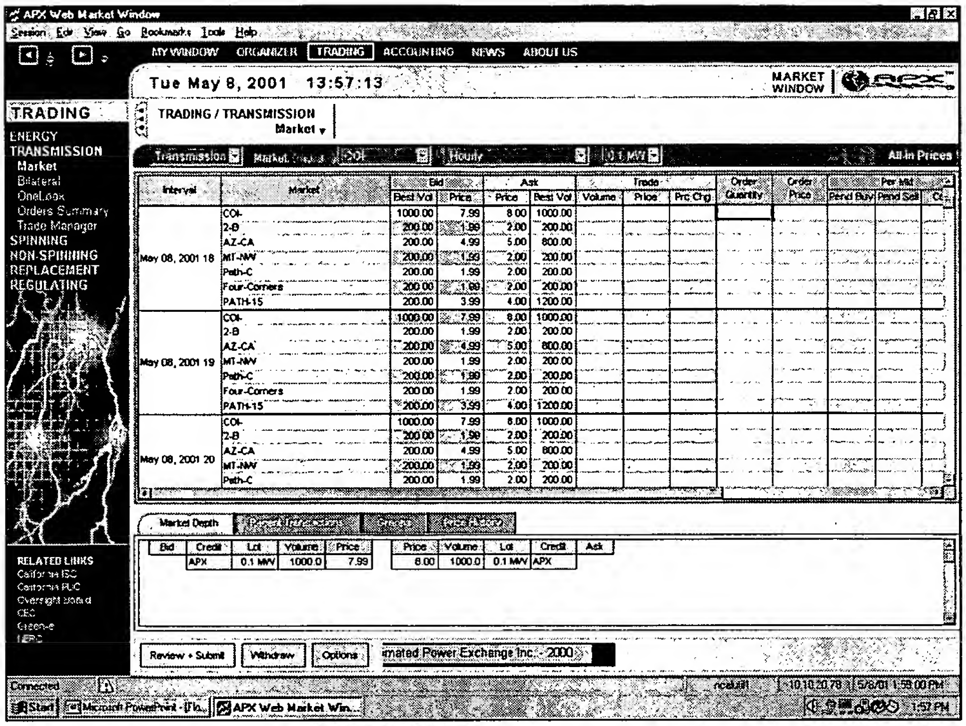
When the participant has selected the products he/she wishes to buy, the participant clicks the "Submit Orders" button to execute all the trades.



The system responds by showing that an order has been submitted and, within a second or two, the order has been contracted.

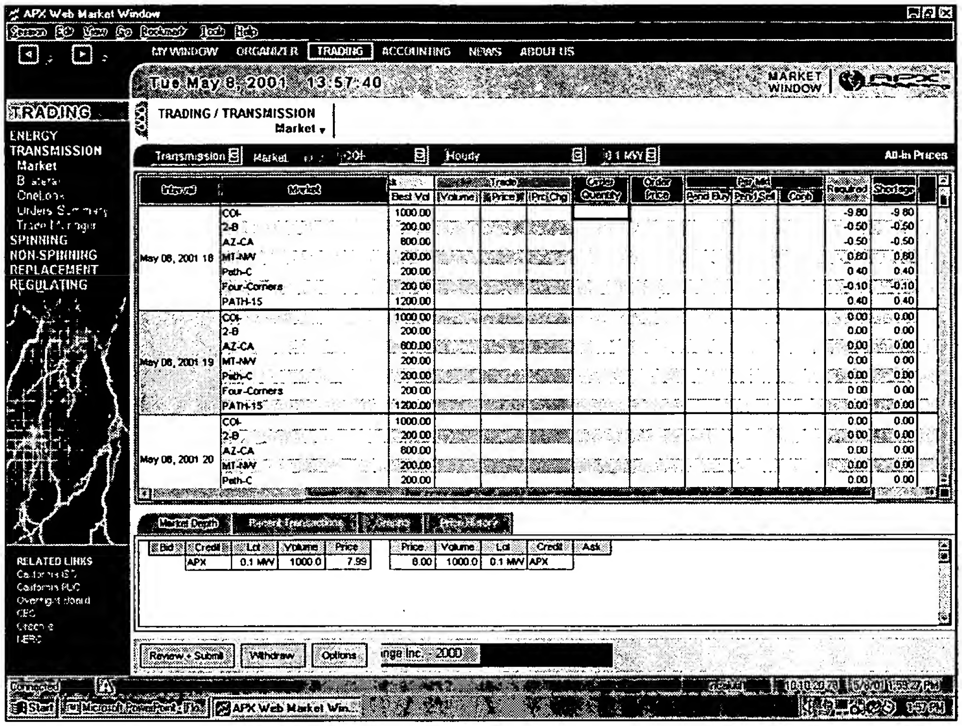


The resulting 10 MW contract is now shown in the "Per Mkt--Contracted" column to the right of the "Order Quantity" and "Order Price" columns.

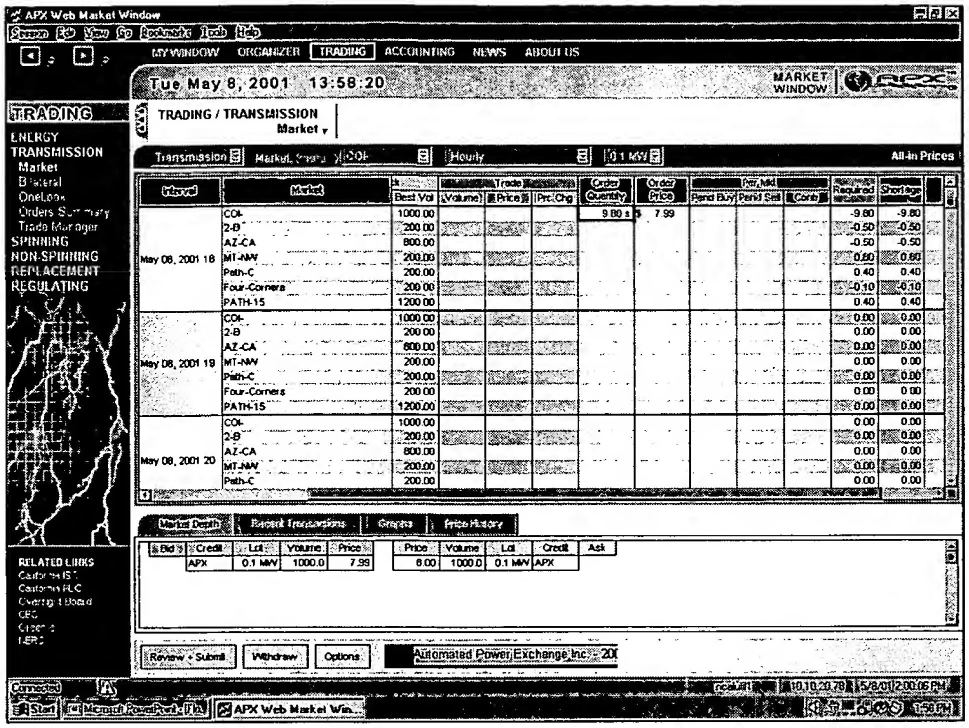


Now let's look at the flowgate market screen. To access the flowgate market screen, the participant would click on "Transmission" to the right of the screen. The trading screen that will appear looks very similar to the energy trading screen we just examined. However, instead of having markets representing energy trading hubs, the markets would be flowgates.

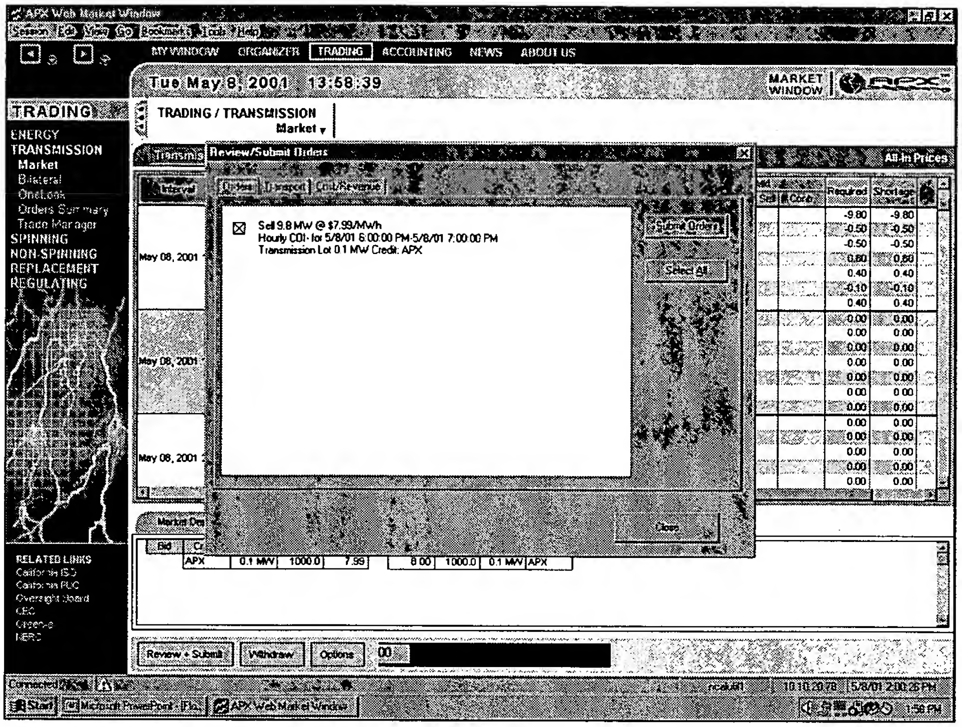
For each flowgate, a bid and offer ("ask") stack would be shown at the bottom of the screen.



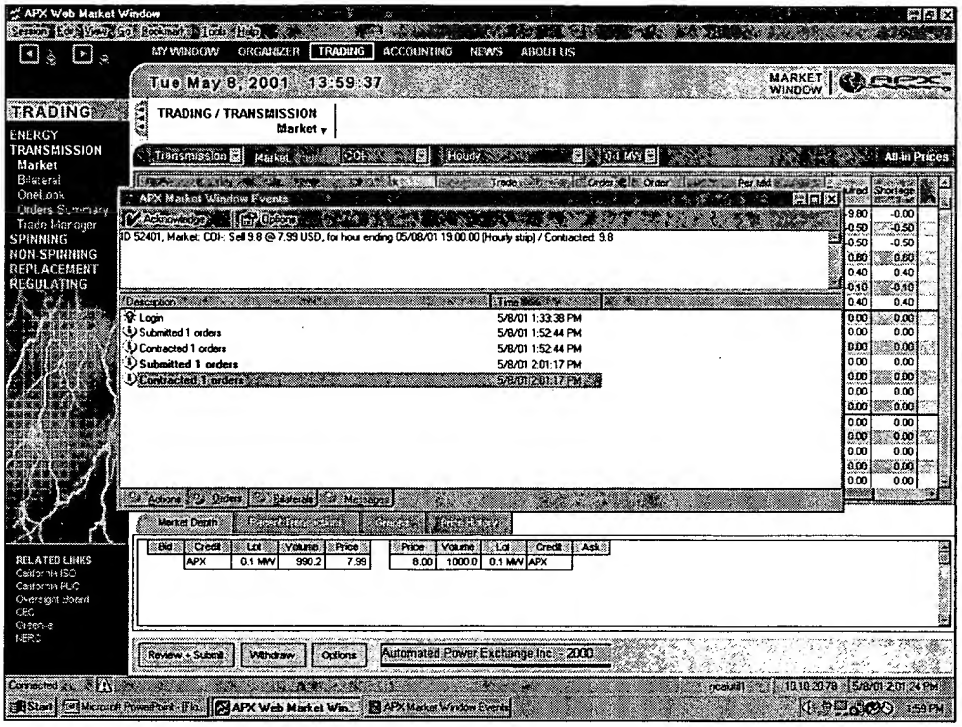
The flowgate trading screens would have two additional columns not shown on the energy trading screens, "Required" and "Shortage". The "Required" column would show the amount of each flowgate needed to deliver the energy the participant had contracted for through the energy trading screens. The "Shortage" column indicates the remaining amount of this flowgate that the participant still needs to procure in order to deliver the energy the participant had contracted for through the energy trading screens. The "Shortage" column is simply the difference between the "Required" column and the "Contracted" column. These columns allow the participant to easily track and trade the transmission needed to deliver their energy.



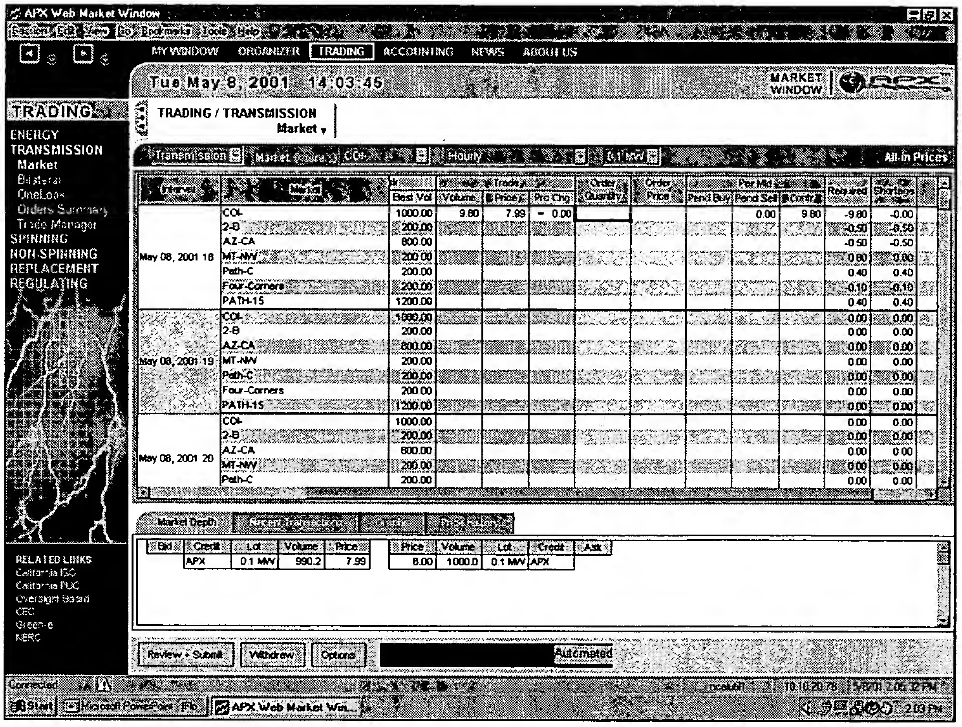
The participant would place a flowgate order much like an energy order. In this example, the "Required" column is negative, indicating that the participant's energy contracts have created a counterflow, allowing him/her to sell the flowgate. So, the participant places an order to sell 9.8 MWs of the COI flowgate at the bid price of $7.99.



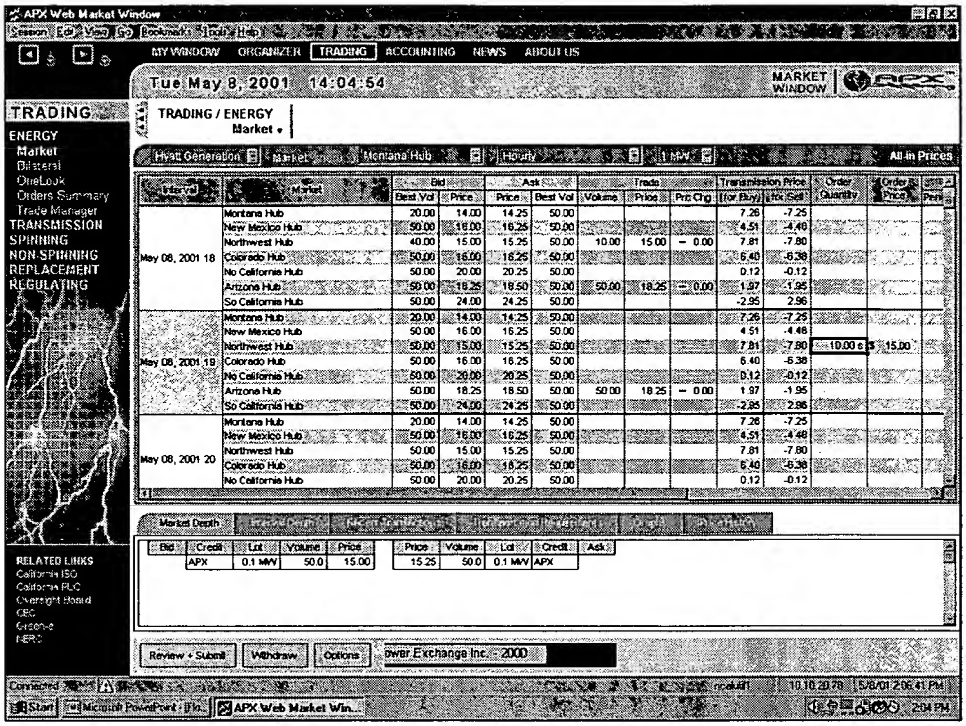
The participant then clicks the "Review and Submit" button, which brings up a screen confirming the participant's order. Assuming the order is correct, the participant clicks "Submit Orders".



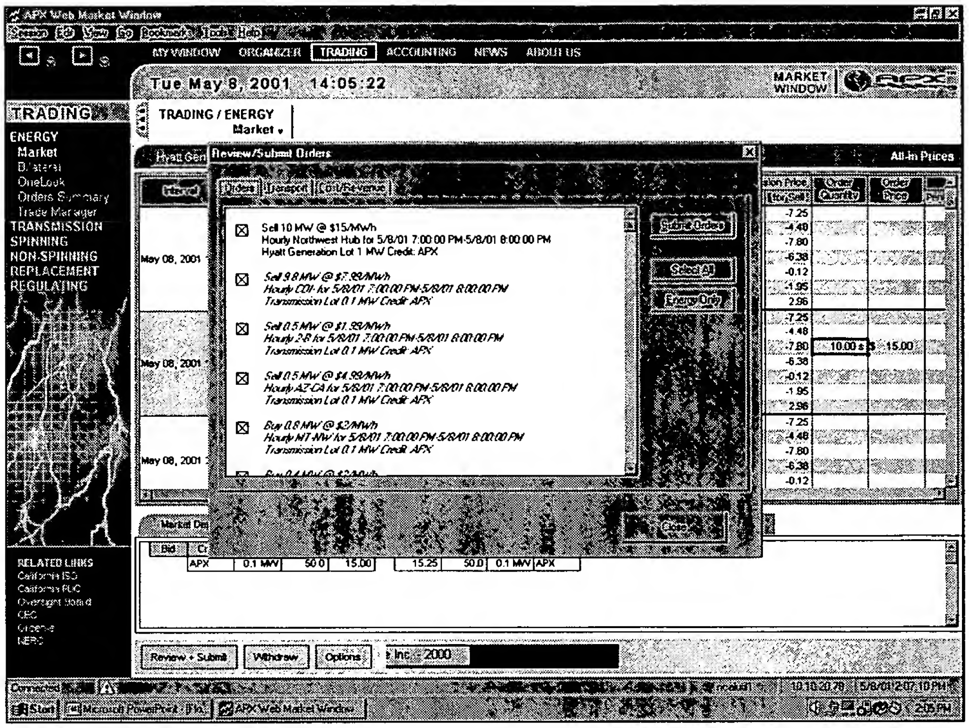
The order is submitted, and contracts. The user could enter orders for all the required flowgates, and submit them through this flowgate trading screen.



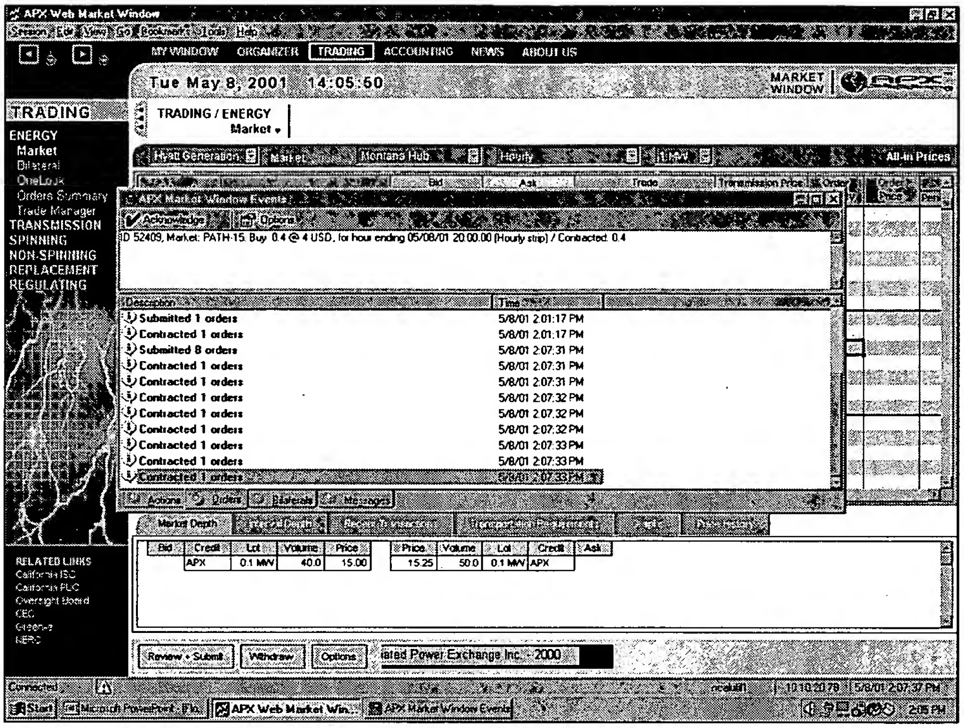
We see that the 'Shortage" for the COI flowgate is now equal to zero.



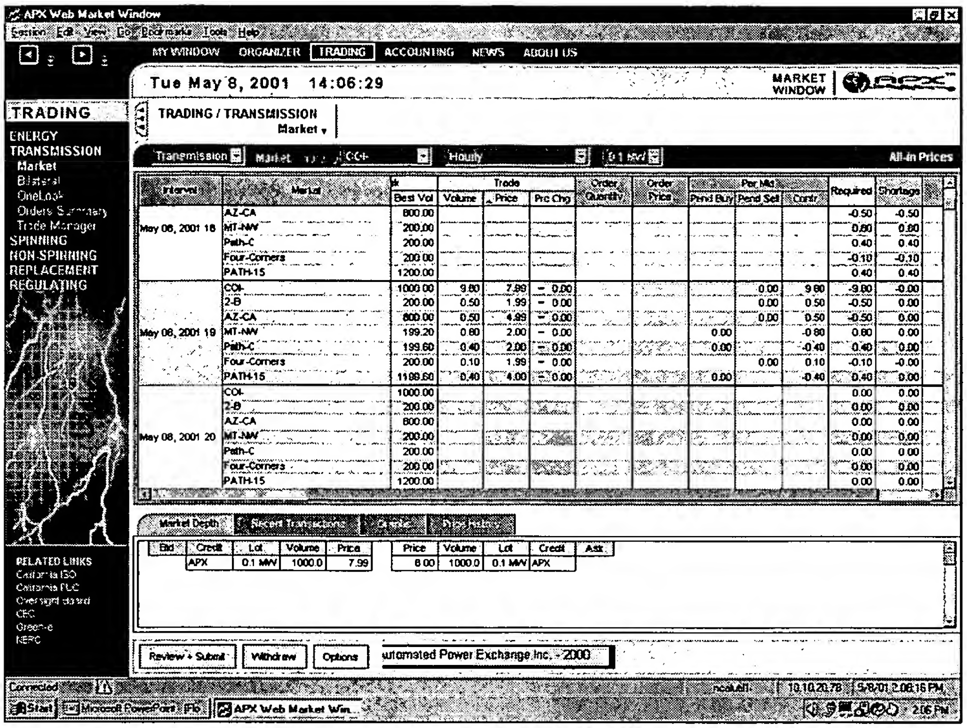
There is, however, an easier way to procure energy and flowgates all at once. Returning to the energy trading screen, we again place an order to sell energy in the Northwest.



The participant clicks "Review and Submit". A listing of the energy order, along with all of the flowgates required to deliver the energy appears. Assuming the participant wishes to procure energy and flowgates together, he/she simply leaves all the flowgate products checked and clicks "Submit Orders".



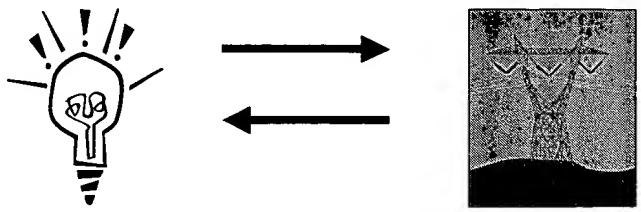
Both the energy and flowgate orders are submitted simultaneously, and contract immediately. The participant has procured both energy and flowgates. An additional button could be added to submit a schedule for the transaction to the system operator. Since the system already has all the schedule information, no further user intervention would be required in this process. In fact, the system could be configured to submit a schedule automatically whenever the participant does an energy transaction and has procured the needed transmission.



If we go back to the flowgate market screen, we see that that for this hour (hour 19), the customer has contracted for each of the flowgates in an amount equal to the "Required" amount, and that the "Shortage" is zero.

APX Market Vision

Energy Market | Transmission Market



Easily find best energy deal, taking into account the transmission costs

Easily track and trade flowgate rights needed to deliver the energy

05/01

We have thus shown how APX could offer participants an integrated market for energy and transmission. Users can easily identify the energy deal that is best for them taking into account transmission costs, and track and trade the transmission needed to deliver the energy.